

SEMI ANNUAL STATUS REPORT

(November 1965 to 30 April 1966)

INVESTIGATION OF RADAR ECHOES FROM THE MOON
AND PLANETS USING METHODS AND DATA FROM
EARTH RADAR-RETURN STUDIES

Progress Report PR-66

by

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1.0 INTRODUCTION

In this report are summarized the theoretical research activities carried out during the period 1 November 1965 to 30 April 1966 and a list of topics for future study. As in the past the purpose of the research has been to devise improved means of obtaining estimates of the electromagnetic and roughness parameters of distant inaccessible scattering surfaces. In general, the approach has been directed toward the obtaining of vector solutions for the scattered fields at the observation point so that direct- and cross-polarized components may be subjected to separate analysis. Dependence of these components on certain controllable parameters (frequency, pulse length, bistatic separation of transmitter and receiver, transmitted polarization, among others) should make possible the separation of electromagnetic and roughness effects. The concept of differential reflectivity¹ has been a major tool in the research activities under grant NsG-129. During the current report period work has been principally directed toward specific problems relating to: (1) scattering, (monostatic and bistatic) from a statistically configured surface illuminated by pulsed radar, and (2) the determination of electromagnetic properties (including conductivity) of a smooth spherical surface from several bistatic power measurements.

¹Erteza, A., J.A. Doran and D.H. Lenhert, "Concept of Differential Reflectivity as Applied to the Reflection of Beam-Limited Radiation by a Convex Body," RADIO SCIENCE, Journal of Research NBS/USNC-URSI, Vol. 69D, No. 2, February 1965.

a normally distributed (in height from an average sphere) surface for the condition that the ratio of standard deviation to correlation distance is much less than one over the square root of the radius of the sphere in wavelengths. Comparison of this solution with experimental data indicates that the moon must have a roughness characterized by a much larger value of this ratio. The minimum value of dielectric constant obtained from this analysis equals $1.82\epsilon_0$.

This analysis shows that the $\text{Re}[\vec{E} \times \vec{H}^*]$ can be used for the time averaged power from a pulsed source only in a portion of the return pulse and then only if the standard deviation of heights is greater than one-tenth of a wavelength. The analysis also shows that any statistical matching with experimental data must take into consideration the angular variation of the reflection coefficients. Results of this analysis clearly establish that the shape of the return pulse from a lunar back-scatter experiment, after the trailing edge of the pulse has passed the sub-radar point, is caused entirely by the roughness of the surface.

2.2 Determination of Electromagnetic Parameters of A Smooth Spherical Body

As outlined in our previous report, efforts were made to obtain ϵ and μ in terms of the ratio of the direct- and cross-polarized powers scattered by the body. A paper covering this work will appear in the August 1966 issue of Radio Science. Subsequently, an investigation was undertaken to ascertain whether it would be possible to determine, by a

similar means, conductivity as well. This effort was abandoned when it was concluded that even though the necessary expressions could be derived the measurements of the field quantities would require extraordinary precision not likely of attainment in the foreseeable future.

2.3 Bistatic Scattering from a Rough Sphere

Work has commenced on a study leading to a vector solution for the problem of bistatic scattering from a statistically rough, generally spherical surface. The existence of such a solution would even today, when we are acquiring a capability for placing radiating systems into extraterrestrial trajectories, be of immense value in the estimation of the surface properties of objects such as our moon, and the planets and their moons. It is contended that information concerning the surface roughness characteristics and the average values of the electrical parameters may be more easily extracted from bistatic return measurements than from those for the monostatic case.

3.0 FUTURE WORK

3.1 Continuation of Monostatic Scattering Study

The investigation described in Section 2.1 will be continued with the major emphasis on relaxation of the convergence criterion in order to expand the range of validity of the solution to larger values of the ratio of standard deviation of surface heights to correlation distance. This work will be pursued in order to obtain a better match with experimental lunar back-scatter data.

3.2 Continuation of Bistatic Scattering Study

This study will be continued, with the initial emphasis on the obtaining of solutions for CW illumination of the surface. On the completion of this phase of the work solutions will be obtained for the more realistic situation wherein the illumination is that from a pulsed radar. In addition, solutions will be obtained using the differential reflectivity approach as well as by a more conventional Kirchhoff-Huygens approach in order to obtain additional evidence supporting the thesis that differential reflectivity is singularly well suited to the task of solving scattering problems of this nature. We note here that the Kirchhoff-Huygens approach approximates the incident field at a surface point by an infinite plane wave and the differential reflectivity approach does not require this assumption.

4.0 PAPERS AND REPORTS

Accepted for publication was:

Erteza, A., and J.A. Doran, "A Bistatic Radar Method for the Determination of ϵ and μ for a Smooth Spherical Target," Radio Science, Vol. 1, No. 8, August 1966.

Being submitted as a separate report emanating from this contract is:

Lenhert, D.H. and A. Erteza, "Effects of Surface Roughness on Radar Backscatter from A Spherical Surface," University of New Mexico Bureau of Engineering Research Report No. EE-132, May 1966.

In preparation are: (1) A journal article by Dr. Lenhert covering certain portions of his Ph.D. dissertation

and (2) letters to IEEE Transactions on certain results of our investigation.

5.0 TRAVEL

No trips were taken during this report period.